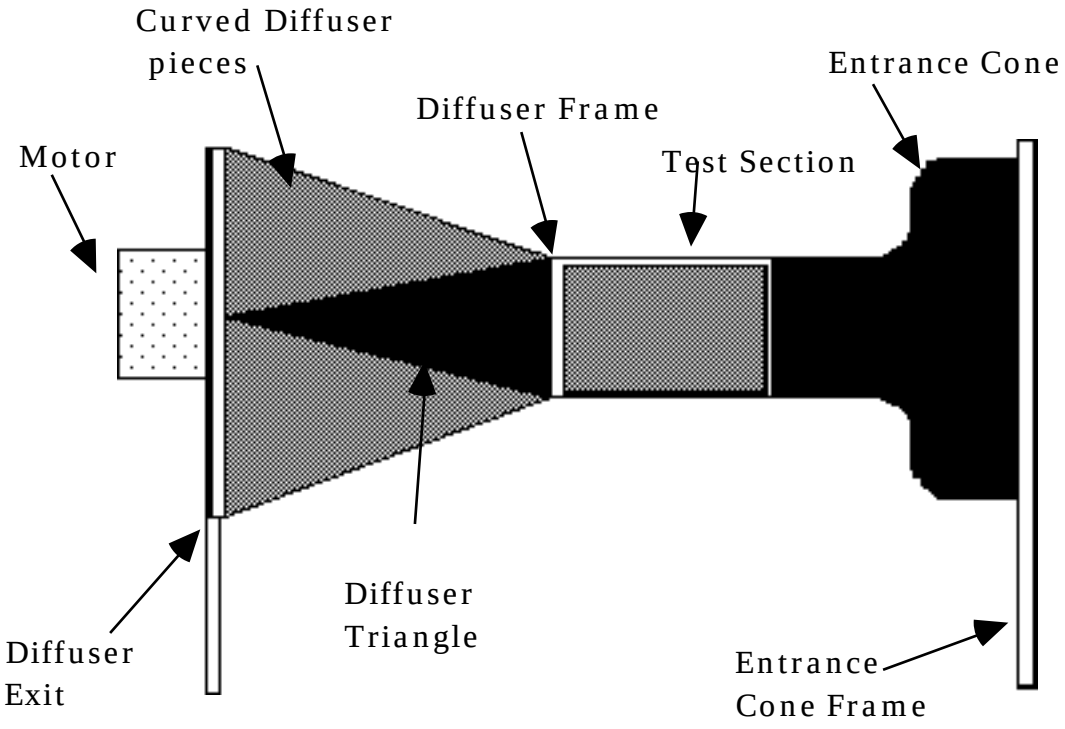
Wind Tunnel Assembly



DIFFUSER SECTION

• Wood Frames

To build the diffuser section, construct a wood frame for the upstream end according to the Diffuser Frame plan and cut a 3/4 inch plywood sheet for the Diffuser Exit according to the Diffuser Exit plan.

• The Triangles

Cut the four triangular top, bottom, and side pieces from flat 1/4 inch plywood according to the Diffuser top and bottom Dimensions template. Using the small ends of these triangular pieces as a guide, cut out the four notches in the 3/4 inch Diffuser Exit piece. Now fit the 4 triangular pieces into the wood frame, holding them temporarily in place with masking tape. Make sure the inside of the plywood pieces fit flush with the inside of the frame. Lay the 3/4 inch Diffuser Exit on a flat surface, notch side up. Making sure the top of the wood frame is lined up with the top of the Diffuser exit and with the triangular pieces hanging from the frame, fit these triangular sides, top, and bottom into the notches in the Diffuser Exit.

When everything looks okay, add epoxy to all joints and reassemble, holding everything together with small brads until the epoxy sets.

• The Curved Surfaces

The curved surfaces between the top and side triangular pieces are formed with tag board available from art supply stores. Cut this tag board about 1/8 inch larger than the opening. Cut three more pieces of tag board this same size since all openings are the same. Temporarily tape the tag board on the inside of the diffuser using 1/2 inch masking tape. From the outside, run a fillet of epoxy or polyester resin around the perimeter of the tag opening. Cut four pieces of 7 oz. fiberglass cloth the same size as the exposed tag board. Brush a coat of polyester resin through the fiberglass cloth to saturate both the glass and tag board. If more stiffness is desired, a second layer of fiberglass can be added.

THE ENTRANCE CONE

•Assembling Frames

Construct a simple wood frame for the front of the Entrance Cone according to the specifications for the Entrance Cone frame. The back of the Entrance Cone (where it joins the test section) is a wooden frame constructed just like the Diffuser Frame.

•Assembling Boards

Cut the Entrance Cone top, bottom, and sides using the coordinates from the "Entrance Cone Template" drawings. Cut the curved surfaces from thin poster board available at art supply stores. Pre-bend the curvature of the poster board top, bottom, and sides to their approximate finished shape, then glue each piece to its corresponding notch cut in the large entrance cone's frame. Temporarily tape together the edges of the entrance cone's curved sides. Slip the entrance cone exit frame over the exit end of the poster board curved surfaces. Permanently glue the edges of the board together with a fillet of waterproof adhesive such as epoxy. After the glue has set, remove the tape and set the entrance cone face down on a flat surface.

Measure from the exit of the entrance cone to the flat surface to make sure that the exit is parallel to the entrance. Trim the exit if necessary. Now glue the exit frame to the poster board exit using masking tape to temporarily hold the poster board to the exit.

• Hardening The Posterboard

Carefully lay a layer of 7 oz. fiberglass cloth on one side of the entrance cone. Cut the cloth such that each end just touches the wood frames. Let the sides extend past the edges 1/2 to 1 inch. Brush a coat of polyester resin through the fiberglass to saturate both the glass and poster board. Let the resin partially harden, then use a razor blade to trim the edges flush with the sides. If more stiffness is desired , a second layer of fiberglass cloth can be added.

• The Flow Straightener

The ideal flow straightener for the 7 X 10 inch wind tunnel is a 1/4 inch cell by 1 inch thick phenolic or aluminum honeycomb. If this cannot be found, two layers of "egg crate" florescent light diffuser that have been glued back to back give adequate results. Use model airplane glue or Super glue to bond both halves together, being careful to align the halves as best you can. Saw the "egg crate" to a size slightly larger than 14 X 20 inches, then carefully trim the edges such that it fits snugly into the front part of the entrance cone. When fitted properly, it will secure itself in place by friction only.

TEST SECTION

• The Plexiglas Pieces

To construct the test section, cut all test section pieces from a 12 x 36 inch piece of 1/4 inch Plexiglas according to the Test Section plan. Cut the top, bottom and sides to exactly fit into the wooden frame at each end of the test section. With the Entrance Cone facing down (large end down) place the Plexiglas top, bottom, and sides in the Entrance Cone frame, temporarily holding the pieces together with tape. Mark each piece of Plexiglas, identifying each piece and its orientation so that there will be no confusion as to what piece goes where during assembly. Drill through the existing holes in the wood frame with a #32 drill bit and into the Plexiglas only about 1/32 of an inch. After each of the four pieces of Plexiglas have been "spotted" in this manner, remove the Plexiglas from the frame and drill each "spot" with a #43 drill and then tap each hole with a 4-40 tap. Lay out and drill the 4-40 clearance holes (#32 Drill) along the bottom edges of the side pieces and also at each end of the top piece. Countersink the outside of these drilled holes (not the tapped holes) with a 1/4 inch 82° countersink. Reassemble the Plexiglas pieces into the Entrance Cone frame using 4-40 x 3/4 flat head machine screws. "Spot" the six (6) holes in the bottom Plexiglas piece using a #32 drill through the holes that were just countersunk. Also "spot" the two holes in the top edge of the side

pieces. Disassemble once again and then drill the "spotted" holes 1/2 inch deep using a #43 drill. (Wrap a small piece of masking tape 1/2 inch from the tip of the drill to act as a drill depth gauge.) Tap there drilled holes for a 4-40 machine screw.
Lay out a precise longitudinal centerline on both the Plexiglas bottom and top door pieces. Carefully scribe both centerlines. These lines are used as a reference for setting tunnel models at zero degrees angle of attack prior to testing. Assemble the four pieces of Plexiglas test section using 4-40 x 1/2 flat head machine screws where appropriate. Set the Plexiglas test section on the diffuser frame and "spot" the eight (8) screw holes as before then drill (#43) and tap the holes. Screw the test section to the Diffuser and Entrance Cone using 4-40 x 3/4 flat head screws. Now carefully trim the Door on the top of the test section such that its sides are flush with the test section sides and there is no gap between the top and the door. attach the door to the top using two 3/4 inch brass hinges, and 4-40 machine screws.

MOTOR/FAN MOUNTING

The Fan Screen with the motor mounting slots must be cut down in diameter to a dimension somewhere between 16 and 17 inches. The Motor should be 1/4 HP, 1625 RPM, 2.7A, 110V, 60 Hz, AC 3-speed and should mount directly to the outside of this screen with four 10-32 nuts and washers.

• The Fan
The fan should be mounted close to the screen, maintaining about 1/4 inch clearance from the screen. The Fan Blade is mounted such that the blade hub flange is facing upstream. When mounting the Fan Blade, make sure that the set screw is tight. Add a drop of Lucite on the set screw threads for added insurance against vibration loosening the Fan Blade. Further security can be attained by drilling a slight dimple on the motor shaft where the set screw contacts the shaft.

Set the finished diffuser section with the exit facing up. The Fan/Motor/Screen assembly is then placed on top of the exit. Carefully position the Fan assembly so that the blade is centered in the opening and you have at least 1/16 inch blade tip clearance. Fasten the screen to the 3/4 inch plywood with four metal screen chips screwed to the wood with #8x1 sheet metal screws. Place a 3/4 inch by 1/8 thick foam pad under each Screen Clip.

As for the motor hookup, the motor starting capacitor is attached to the motor with a strap. The motor controls are housed in a 4 inch duplex box mounted on the outside of the 3/4 inch plywood Diffuser exit. This box houses the three speed fan switch as well as variable speed motor control that is connected in series with the high speed motor winding wire. Verify that the motor rotation is counterclockwise when facing upstream. Protect all wires and connections between the motor and the control box with a flexible conduit.

CENTERBODY AND SCREEN

The Centerbody's function is to divert the air around the fan hub in a controlled manner so as to preclude and flow separation in the diffuser section. Since the aerodynamic loads on the centerbody are quite low, it can be made from very light weight materials such as Styrofoam. Cut the desired profile shape in block form on a band saw, then round off the square corners with a knife. Cut a 6 1/2 inch diameter disc of 1/4 inch plywood with a 2 inch hole bored in the center. Securely bond this disc to the flat end of the Styrofoam with a slurry of epoxy and micro balloons. The final round cross section can be achieved by sanding with coarse sandpaper. A strong, hard surface finish can be achieved by applying a thin layer of fiberglass cloth using epoxy. (Do not use polyester resin because it will destroy the Styrofoam). If a model safety screen is to be used (see below), it is important to add this layer of fiberglass so as to ensure a secure bond between the Styrofoam and the 1/4 inch plywood. A small 1 inch diameter by 2 inch deep cavity must be hollowed out of the foam to provide clearance for the fan hub. Mount the Centerbody on the tunnel centerline with about 1/8 inch clearance from the fan blades to the Centerbody.

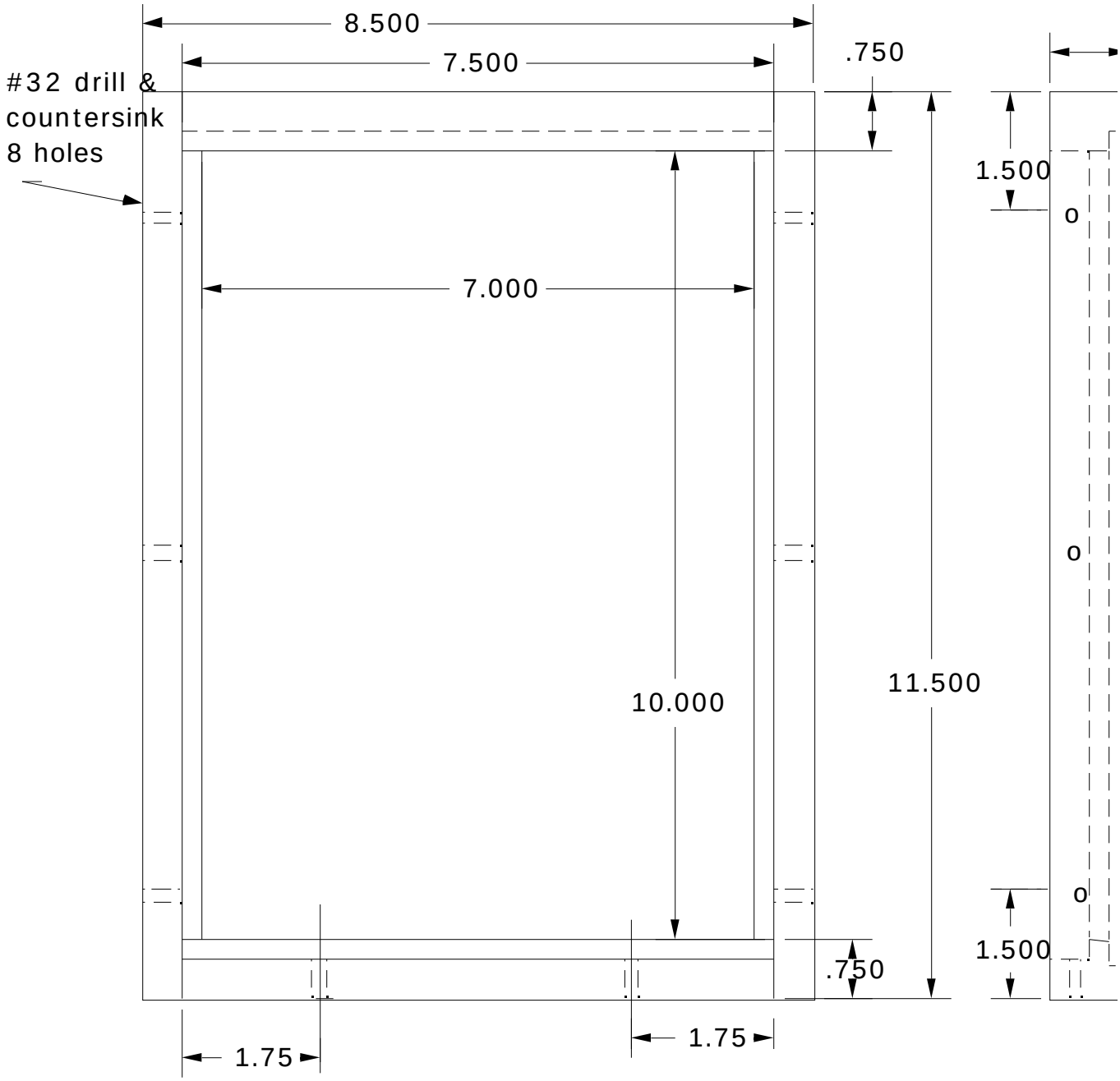
To mount the Centerbody, use two 1/4 inch wood rods. Drill four 1/4 inch holes horizontally through the diffuser sides such that each rod will pass through one diffuser side, through the Centerbody, and into the far diffuser side. Epoxy the rods to the diffuser sides and Centerbody.
If the wind tunnel is to be used in a classroom environment, or you are worried about the possibility of a model going through the fan (with catastrophic results), a model safety screen can be added between the fan blades and the Centerbody. You will pay a slight penalty in maximum air speed, but the tunnel will be much safer in the event a model ever breaks loose. Cut the screen approximately 14 inches in diameter and securely attach it to the Centerbody with four #10 sheet metal screws and wood washers screwed into the 1/4 inch plywood.

FORCE PROBES AND BASE

To measure the "lift" and "drag" of the models in the testing section, we used two Force probes from Vernier Instruments (503) 297 5317. These probes are mounted horizontally and held by two clamps which fit vertically through a 1/2" thick Plexiglas base. The clamps we used were simply three fingered test tube holders which can be ordered from a

chemical supply company. The base also holds a stepper motor that turns the model mount in 0.5º increments both clockwise and counterclockwise. The clamps should be mounted close to 5" from the motor shaft forming a 90° angle from each other. They can be held in place using thumbscrews twisted through a threaded Plexiglas sheath which is attached to the base. Legs should be added to the base to elevate the motor so that it doesn't vibrate. Simple plex rods can be glued in place for this purpose.

Diffuser Frame



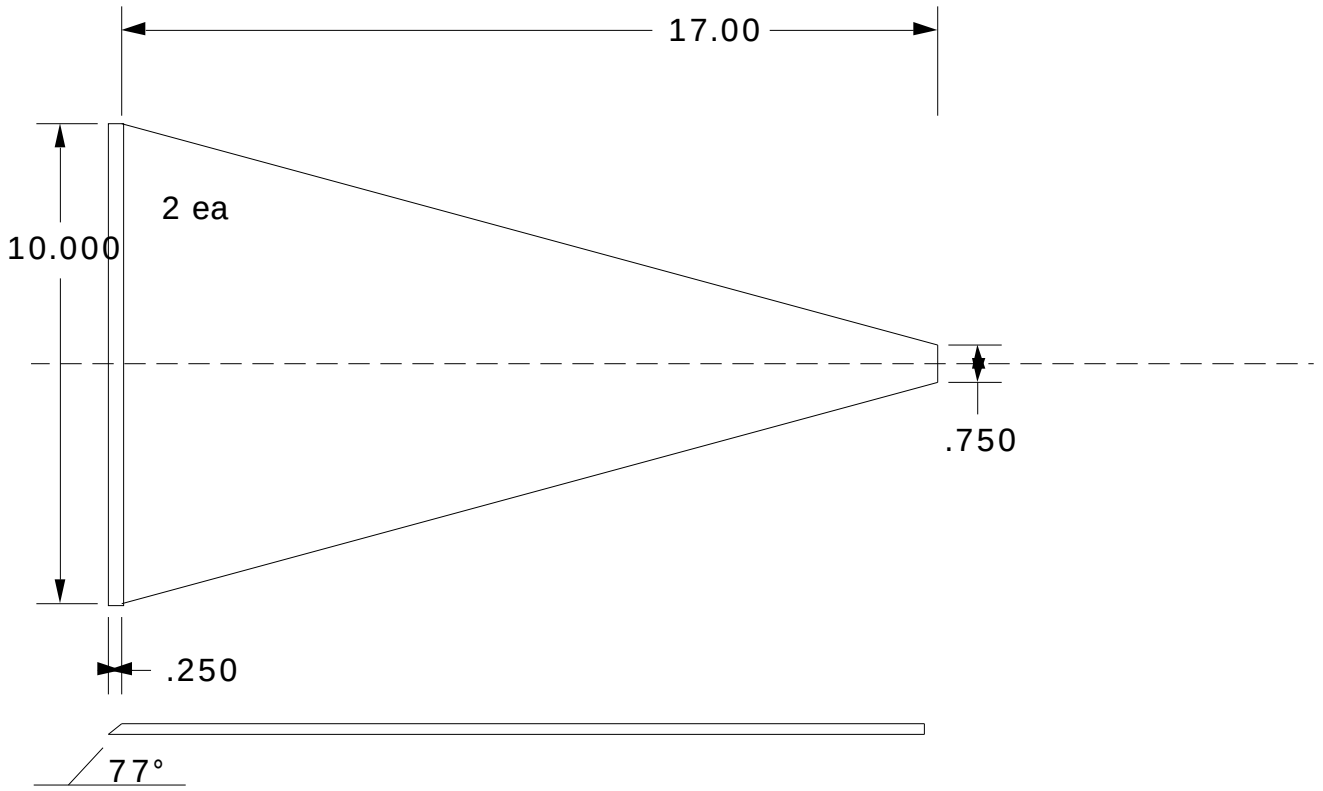
Material: 3/4 Hardwood

Notes:

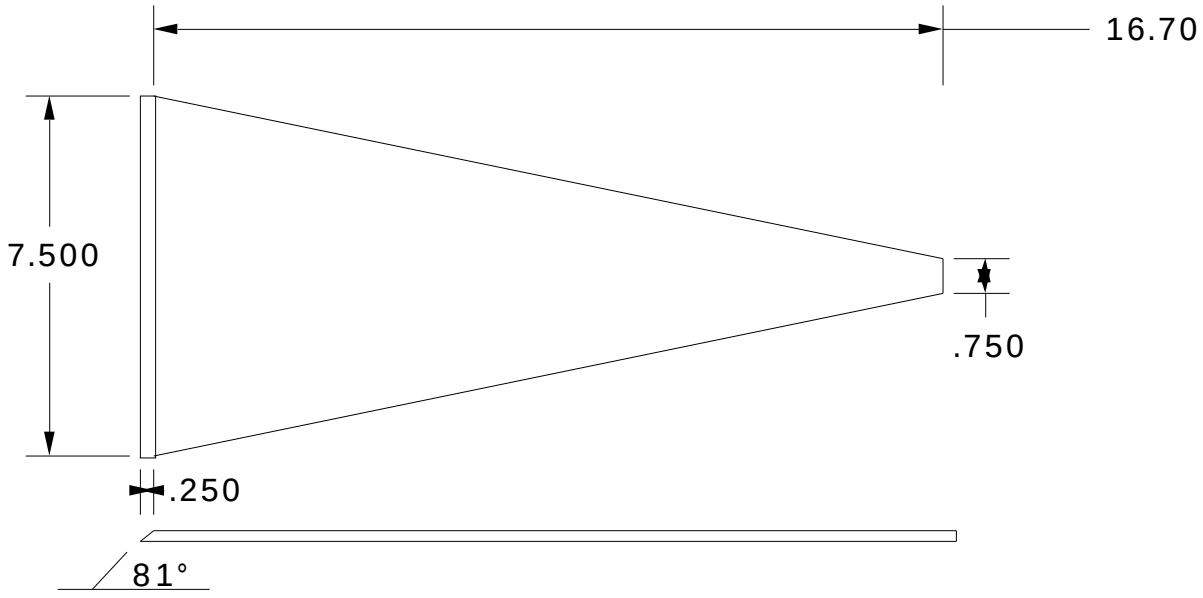
*Drill and countersink all screw holes prior to frame assembly.
*Nail and glue each joint
*Make sure all corners 90°
*1/8" Radius on outside corners
* plexiglass thickness =1/4"
*Plywood thickness= 1/4"

Diffuser Dimensions

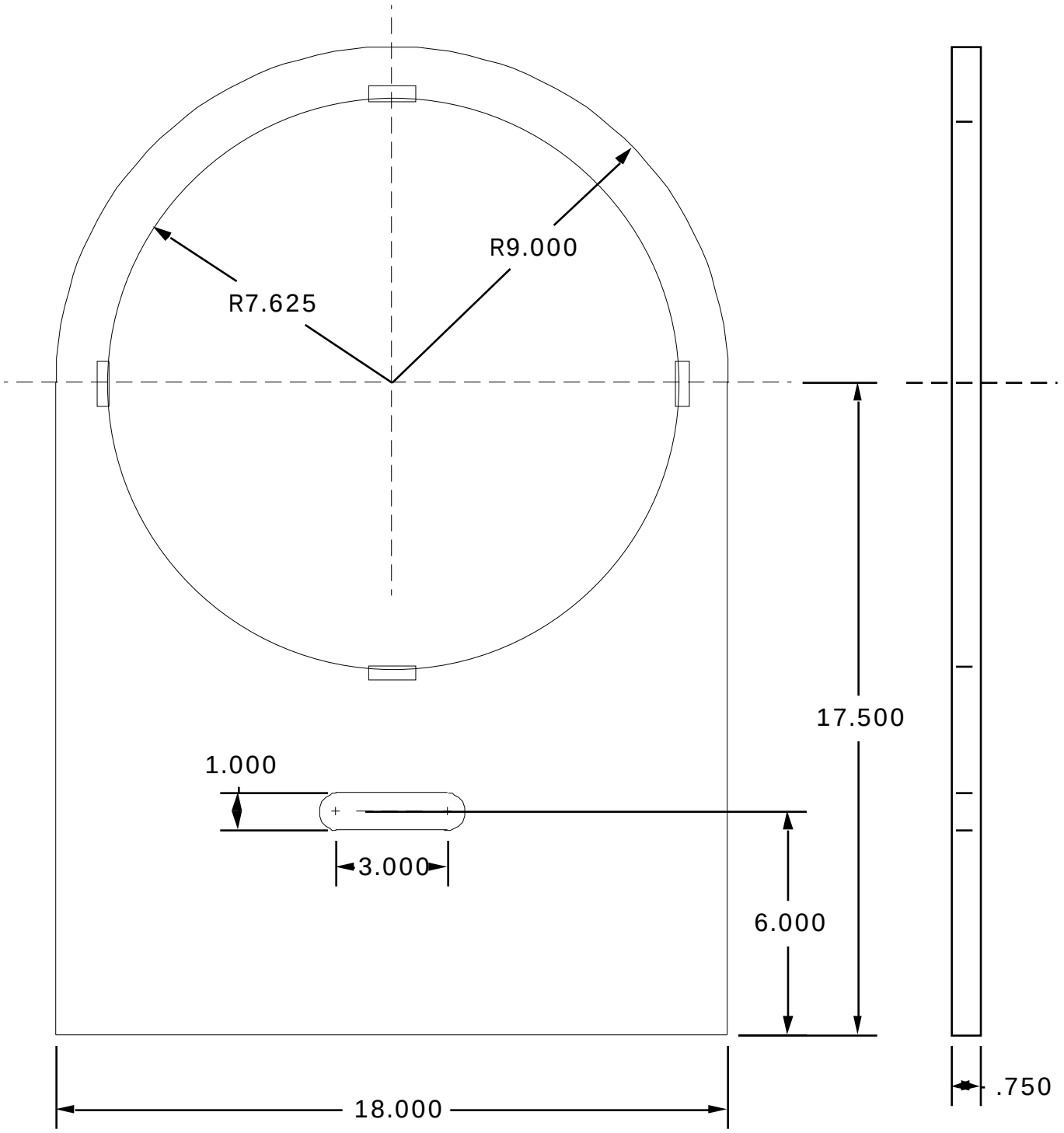
TOP & BOTTOM



SIDES

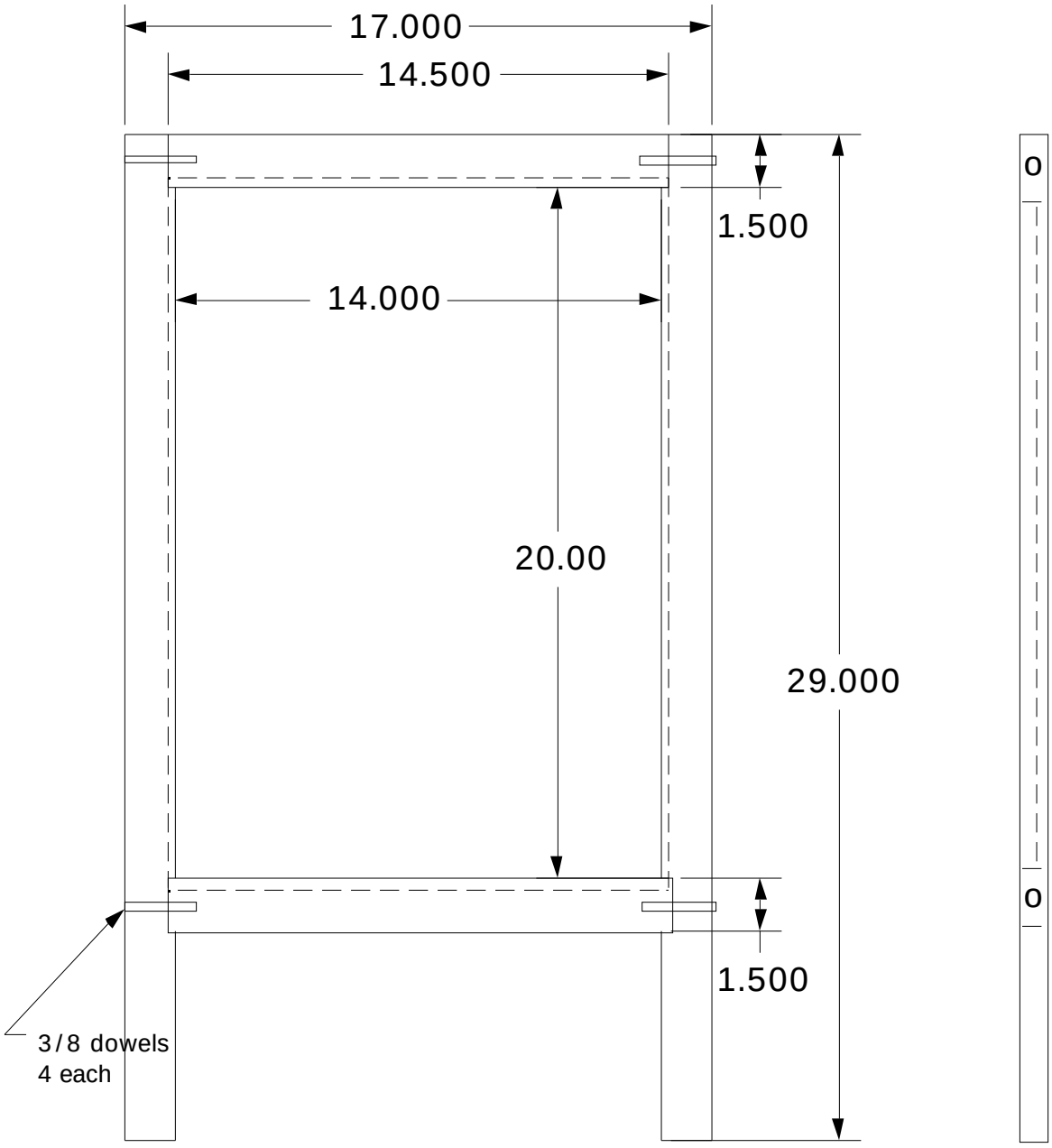


Diffuser Exit



Material: 3/4 Plywood

Entrance Cone Frame



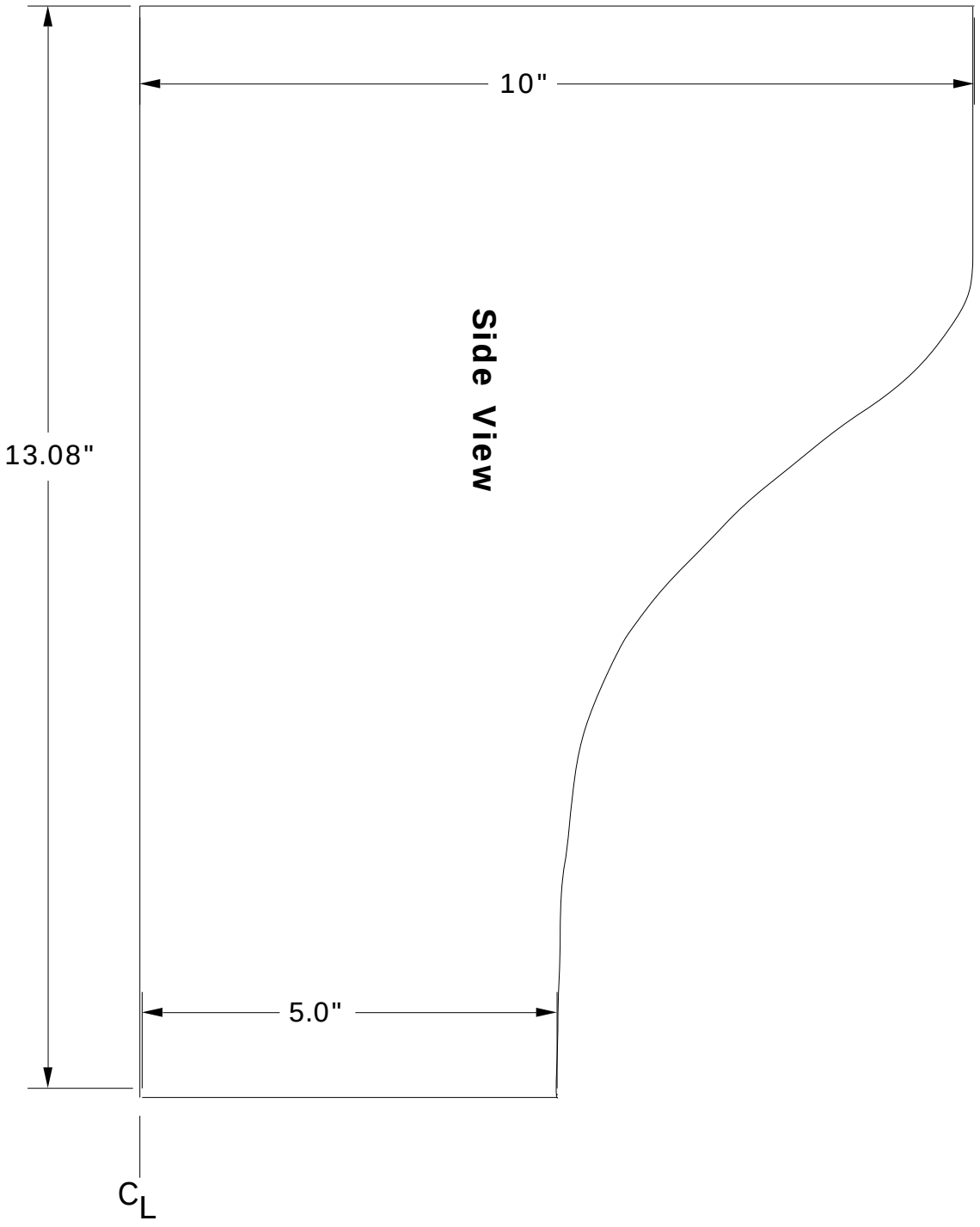
Note:

Mirror image sides

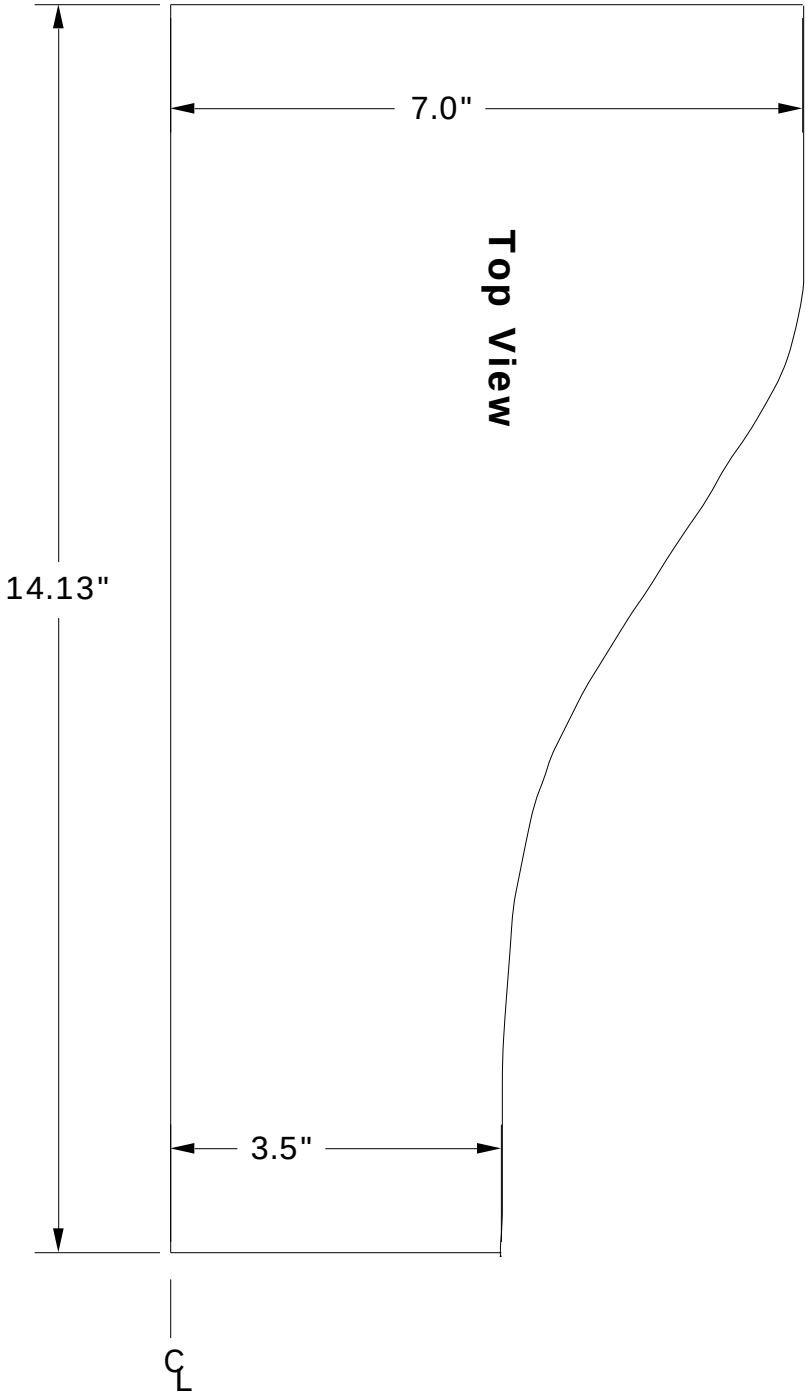
Route 1/2" radius after assembly

Material: 3/4" Hardwood

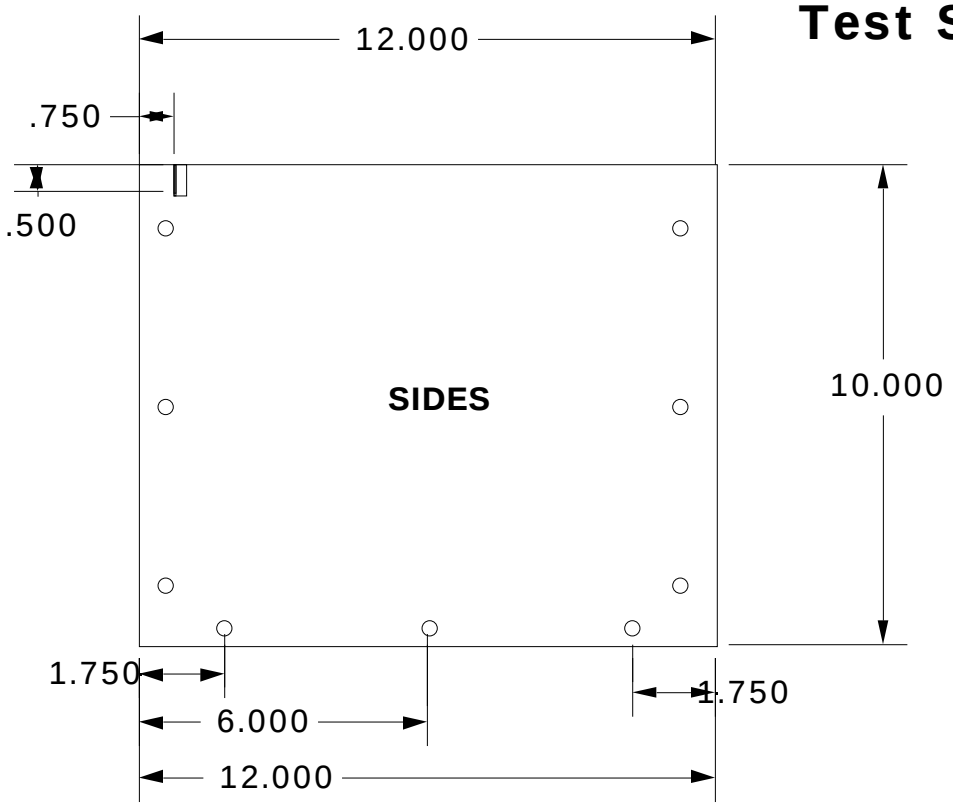
Entrance Cone Template

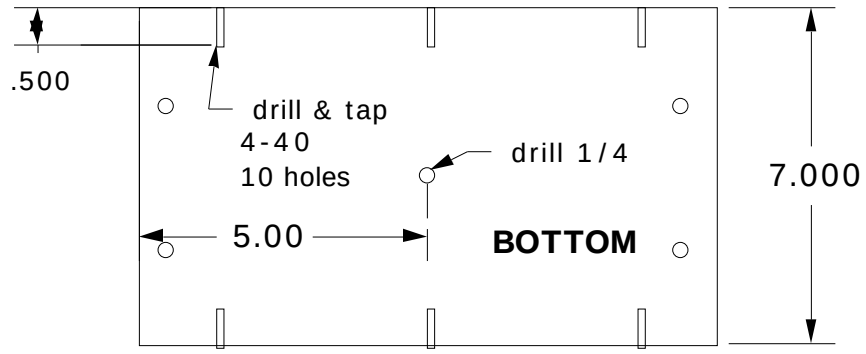


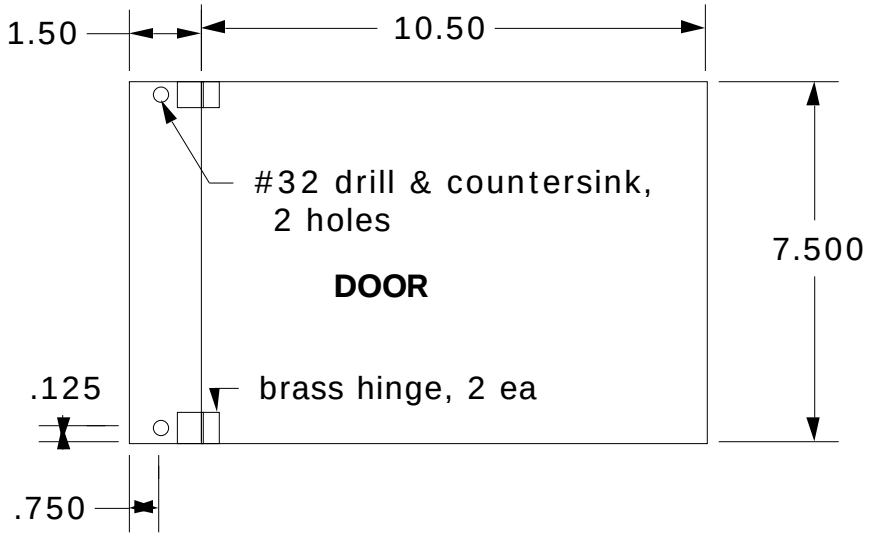
Entrance Cone Template



Test Section

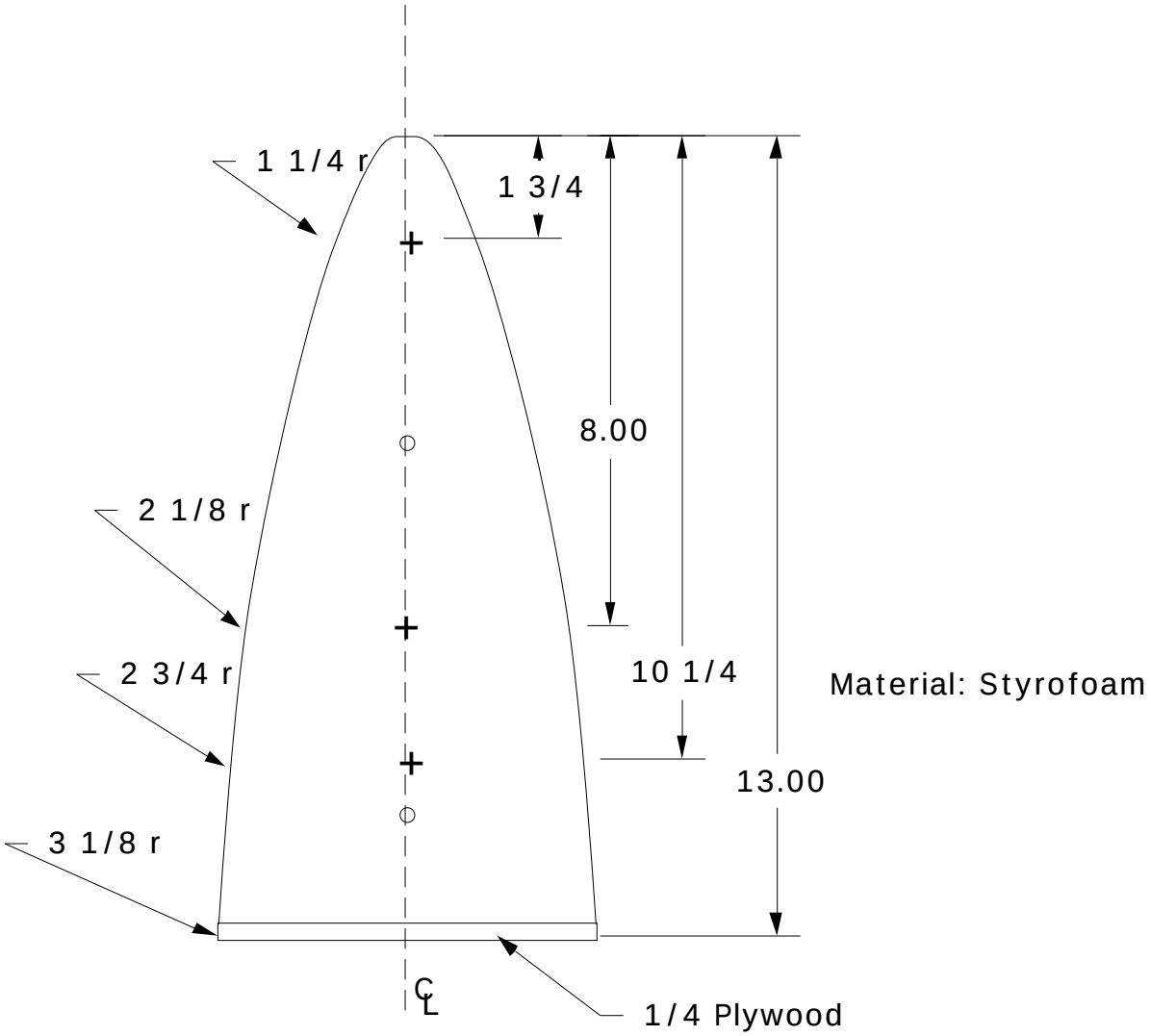




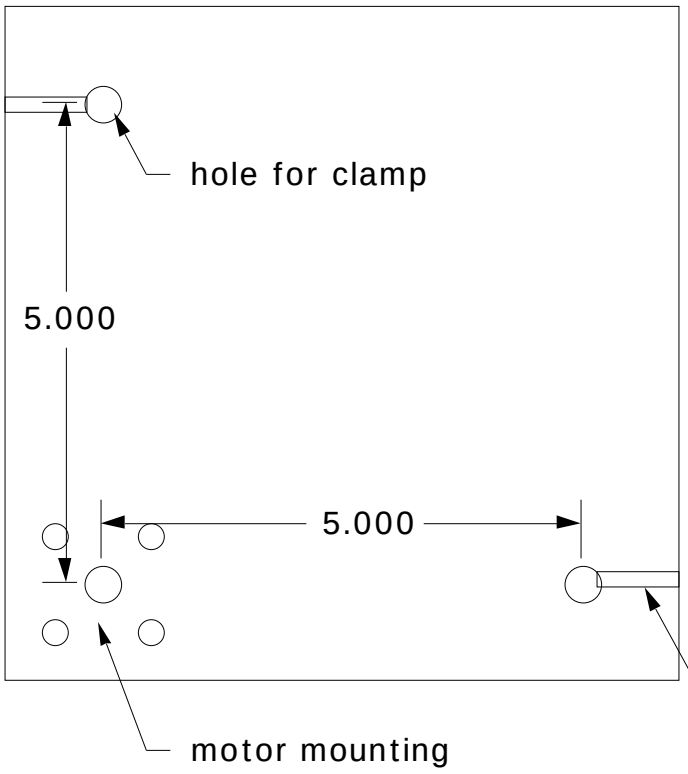


Material: 1/4" plexiglass

Centerbody


1 1/4 r
1 3/4
8.00
2 1/8 r
2 3/4 r
10 1/4
13.00
3 1/8 r
Material: Styrofoam
1/4 Plywood

Base



Top View